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ORIGINAL ARTICLE

Use of cone beam computed tomography to determine the accuracy of panoramic radiological markers: A pilot study

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Abstract *Background/purpose:* Various imaging modalities have been used by clinicians in the preoperative assessment of the third molar position. The purpose of this study is to investigate the diagnostic accuracy of orthopantomography (OPG) markers in determining the anatomical relation between the mandibular third molar and the mandibular canal by comparison using cone beam computed tomography (CBCT).
Materials and methods: Ninety patients' panoramic and CBCT images were chosen for the study. From these, 180 teeth were studied by four trained examiners. The frequency of angulation, Monaco classification, spatial relation, and cortical perforation were detected. The values were then compared using a Chi-square test for both of the imaging modalities.
Results: On OPG, 17.9% superimposition, 22.4% narrowing, 18.4% increased radiolucency, 28.3% interruption, and 13% diversion/deviation were recorded. On CBCT images, 57.8% of the molars were in a direct relation with the inferior alveolar canal and 42.2% had no relation. The statistically significant predictive values of positive test results are narrowing of the canal (72%), and interruption of the radiopaque border with the ratio (77.7%). Of the third molars in a direct relation with the canal, narrowing was recorded in 72% and interruption was recorded in 77.8% of cases with statistical significance.
Conclusion: The presence of narrowing of the canal and interruption of the radiopaque border as radiographic markers on OPG predict contact between the lower third molar

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and inferior alveolar canal. Detailed radiological examination on CBCT is recommended in such cases.

Introduction

Several complications of lower third molar surgery have been reported, including alveolar osteitis, infection, and inferior alveolar nerve (IAN) injury.[1,2] Damage to the IAN is a serious complication following third molar removal. The overall risk of temporary IAN injury associated with third molar removal ranges from 0.4% to 6.0%.[3,4] According to various surveys, the rate of permanent neurological damage is 1% and temporary damage occurs in 5—7% of cases.[5]

Damage of the IAN has been linked to factors such as age, sex, type of anesthesia used, and the experience of the surgeon.[6] The most evident risk factor for injury of the IAN is the proximity of the root of the third molar to the mandibular canal.[7] The risk increases dramatically when there is contact between an impacted molar and the mandibular canal, which is defined as the absence of cortical bone around the alveolar nerve, the point at which the root touches the nerve.[8,9]

Preoperative assessment of the topographic relationship of the impacted mandibular third molar to the inferior alveolar canal (IAC) has been performed by means of different imaging modalities. Each modality comes with its associated package of advantages and disadvantages. Orthopantomography (OPG) has often been cited as the imaging modality of choice prior to the surgical removal of an impacted mandibular third molar.[5]

It is important to assess the position, and establish the relationship, of the third molar with the IAC preoperatively to minimize the risk of nerve injury. OPG is the standard diagnostic tool for this purpose. Clinicians use various radiographic markers to indicate a close relationship between the third molar and the IAC.[8] If the radiological marker on the OPG indicates there is a close relationship between the third molar and the IAC, additional investigation using computed tomography (CT) may be recommended to verify the relationship in three-dimensional view.[10,11] The drawbacks of CT are the higher radiation dose and increased financial costs compared with panoramic imaging.[7]

Cone beam CT (CBCT) scanners have recently been developed for dentomaxillofacial imaging. CBCT reduces the radiation dose,[6,12] offers high spatial resolution and decreases costs,[1] provides better quality images of teeth and their surrounding structures.[13] CBCT examination has been found to be useful in the preoperative diagnosis of lower third molars.[14] To justify the application of CBCT in the preoperative assessment of impacted third molars, it is necessary to assess whether it gives the practitioner a more detailed insight into the anatomical relationship between the third molar and the IAC than conventional imaging techniques.[6]

The aim of this study is to evaluate the diagnostic accuracy of the panoramic radiological markers in determining the relationship between impacted third molars and the IAC by comparison with CBCT.

Materials and methods

Ninety OPG and 90 CBCT images obtained from an imaging center in Ankara (Turkey) were evaluated in this retrospective cohort study. From these, 180 impacted mandibular third molar teeth from 45 male and 45 female patients were included. The mean age of individuals was 29.2 years, with a range from 18 years to 56 years. Two images were excluded because of the existence of a lesion.

Evaluation of images was carried out by three trained radiologists and one maxillofacial surgeon with consensus decision. The observers evaluated first OPG and then CBCT images at 2-week intervals.

Digital panoramic radiographs were taken with Planmeca Proline XC (Helsinki, Finland) operated at 60 kVp, 7 mA, 18 s using charge-coupled device sensor.

On OPG, the anatomical relationship between third molars and the IAC was classified according to Monaco et al's classification consisting of five radiographic markers.[11] They are as follows (Fig. 1A—E): (1) superimposition of the canal with third molar roots; (2) increased radiolucency between the canal and third molar roots; (3) interruption of the radiopaque superior corticated margin of the mandibular canal; (4) diversion/deviation of the mandibular canal; and (5) narrowing of the mandibular canal.

Impacted teeth were also classified according to Pell and Gregory's [15] classification on OPG.

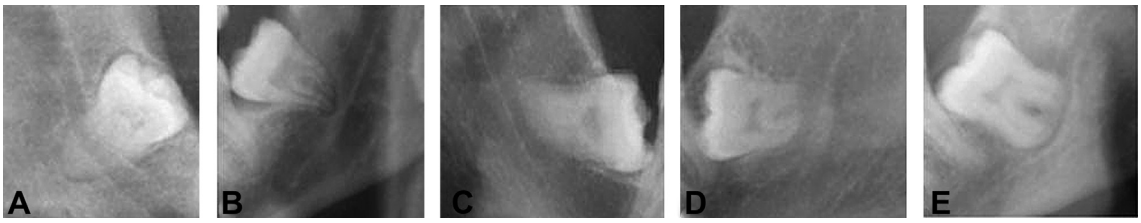

Figure 1 Five radiographic markers on panoramic radiography: (A) superimposition, (B) increased radiolucency, (C) interruption of the radiopaque border, (D) diversion of the mandibular canal, and (E) narrowing of the mandibular canal.

The CBCT images were obtained by using an Iluma Ultra CBCT scanner (3M Imtech, Ardmore, OK, USA) with a 24.4 cm × 19.5 cm amorphous silicon flat panel image detector and a cylindrical volume of reconstruction up to 21.1 cm ×14.2 cm. CBCT images were obtained at 120 kVp, 3.8 mA with an exposure time of 40 seconds and were reconstructed with high resolution (0.2 mm^3) voxel size. The slice thickness was 1 mm. The images were evaluated in all three dimensions. The multiplanar reconstruction screen was used to scroll through the axial, sagittal, and coronal planes. The position of the mandibular canal with respect to the third molar was classified as lingual, buccal, interradicular, and inferior. The perforation of IAC was also noted for each of the third molars.

All data were analyzed using the statistical software package SPSS version 15.0 (IBM, NY, USA). The values for both of the diagnostic modalities (OPG and CBCT) were compared using Chi-square test. Significance level was set at $P < 0.05$.

Results

The study sample consisted of 180 impacted mandibular third molars (90 right and 90 left) from 90 patients (49 male and 41 female). Assessment of OPG revealed that 30.6% (55) of the third molars were in a vertical position, 22.8% (41) were in a mesioangular position, 8.3% (15) were in a distoangular position, and the remaining 38.3% (69) were in a horizontal position.

With statistical significance ($P < 0.05$), 79.7% of the horizontally-impacted third molars had direct relation (cortical perforation) with IAC.

On OPG according to Monaco et al's classification,[11] of the 180 teeth examined in the present study 17.9% (40) superimposition was recorded. Narrowing of the IAC was seen in 22.4% (50) of teeth. Increased radiolucency was detected in 18.4% (41) of teeth and interruption of the radiopaque superior corticated margin of the IAC was seen in the majority of teeth 28.3% (63). Finally, diversion or deviation of the mandibular canal was observed in the remaining 13% (29) of third molars. The detailed results of the radiographic markers obtained on OPG are given in Table 1.

The results of the CBCT evaluation according to spatial relation of mandibular canal and root (lingual, buccal, interradicular, inferior) are given in Table 2. Two-thirds (66.7%) of the cases positioned as lingually had a cortical perforation ($P = 0.013$).

As determined on CBCT images, 57.8% (104) of molars were in a direct relation with the IAC (no cortical bone of the IAC) and the remaining molars (42.2%; 76) had no relation. Of the third molars in direct relation with the canal, narrowing was recorded in 72% (36) of cases and interruption was recorded in 77.8% (49) of instances ($P < 0.05$). In the majority of the third molars without cortical perforation, the radiographic markers' superimposition and deviation were found to be higher than the other markers at 75% (30) and 69% (20), respectively ($P < 0.05$). CBCT-simulated panoramic and coronal cross-sectional images are shown in Fig. 2A–E.

Discussion

An accurate radiographic diagnosis is essential to evaluate and predict the possible outcome related to impacted third molar removal. OPG allows the vertical and two-dimensional relationship between the tooth and the IAC to be assessed. Although OPGs are not sufficient to accurately evaluate the position of the third molar and its relation to the IAC, the cost of CBCT and its unavailability in all centers means that it is inevitable that panoramic radiographies will continue to be used.[16]

According to various surveys, the rate of neurological complications related to the surgical removal of impacted mandibular third molars varies between 0.5% and 1% for permanent damage and temporary damage occurs in between 5% and 7% of cases.[5] The most evident risk factor for injury of the IAN is the proximity of the root of the third molar to the mandibular canal.[7]

The position of the third molar in relation to the mandibular canal is a significant risk factor in the occurrence of IAN exposure. Maegawa et al[10] and Ghaeminia et al[7] reported that the IAN was more frequently exposed during third molar removal when the mandibular canal was positioned at the lingual side or interradicular to the third molar tooth rather than buccally. Howe and Poyton[17] have reported that whenever an intimate relation between the tooth and the canal exists, it is found to be more on the lingual aspect. In line with these researchers in the present study, the lingual course of the canal is found to be associated with cortical perforation of the IAC.

The inferior course of the canal was found by Tantanapornkul et al[18] and Monaco et al[11] to be the most commonly found position. Khan et al[5] reported that of the total number of teeth examined, the mandibular canal was on the lingual side in the majority of instances. In this study,

Table 1 Predictive values, sensitivity, and specificity of the radiographic markers on orthopantomography.

Radiographic marker	Positive predictive value	Negative predictive value	Sensitivity	Specificity
Superimposition	0.25	0.33	0.076	0.67
Narrowing	0.72	0.45	0.27	0.85
Darkening	0.65	0.43	0.2	0.85
Interruption	0.77	0.49	0.37	0.85
Diversion/deviation	0.31	0.37	0.06	0.78

Table 2 Anatomic relation of mandibular canal to third molar.

	n	%
Buccal	42	23.3
Lingual	93	51.7
Inferior	29	16.1
Interradicular	16	8.9
Total	180	100

the lingual course of the canal was found to be the most frequent positioned (51.7%).

Monaco et al[11] identified three radiographic markers on OPG to be predictors of a close relationship between the mandibular canal and third molar roots. These are narrowing of the canal, increased radiolucency, and interruption of the radiopaque border of a mandibular canal. The results of the present study showed that interruption and narrowing of the canal had the highest predictive values among other radiographic markers detected on OPG with percentages of 77.7% and 72.0%, respectively. The percentage of cases with interruption was found to be similar to the values reported in the literature (26—80%). The predictive value of the narrowing was found to be higher than the values reported in the literature (17—59%).[19] In contrast to Monaco et al,[11] in this study no relationship was detected between increased radiolucency and the presence of a cortical break.

Nakagawa et al[20] concluded that in 86% of cases in which the superior white line of the canal was interrupted on OPG, there was cortical perforation between the canal and third molar on CBCT images. Ghaeminia et al[7] found the same in 88% of cases, which is comparable to the results found by Nakagawa et al.[20]

Tantanapornkul et al[18] experienced 27 nerve exposure cases when operating on 142 lower third molars. They stated that interruption was the radiographic sign that best predicted nerve exposure. Contrary to these authors, Gomes et al[21] found no correlation between radiographic markers and nerve damage.

Sewerin and Andreasen[19] evaluated the radiographic marker of superimposition in regard to post-extraction paresthesia. This complication occurred in only 2% of cases in which superimposition was identified on OPG. Paresthesia was present in 33% of cases of diversion, 17% of

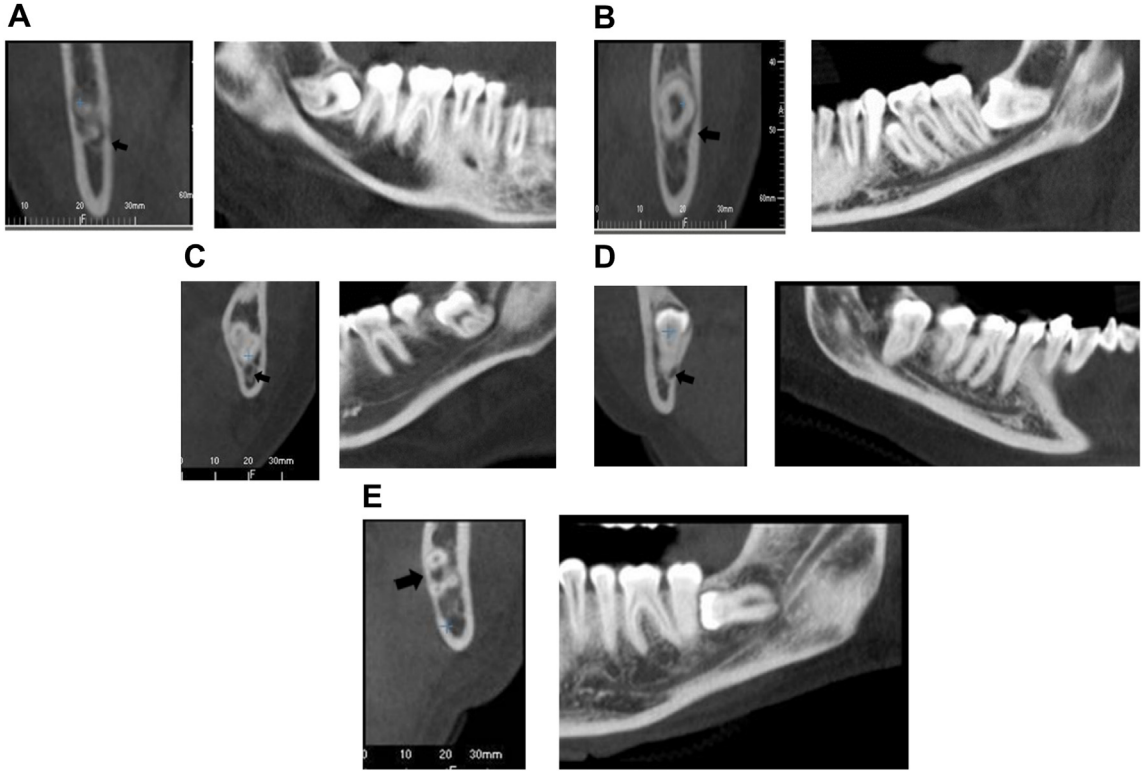

Figure 2 Simulated panoramic images from cone beam computed tomography and coronal images of each radiographic markers. Arrows show the mandibular canal. (A) Panoramic image showing darkening of the roots and coronal image showing disappearance of the cortical layer in the lingual side. (B) Panoramic image showing interruption of the canal and coronal image showing disappearance of the cortical layer in the buccal side. (C) Panoramic image showing diversion of the canal and coronal image showing the presence of the cortical layer on the inferior side of the roots. (D) Panoramic image showing superimposition of the roots on the canal and coronal image showing the disappearance of the cortical layer on the lingual side. (E) Panoramic image showing narrowing of the canal and coronal image showing the disappearance of the cortical layer in the interradicular region.

cases in increased radiolucency, and in 14% of cases of interruption of the radiopaque border.

Khan et al[5] and Monaco et al[11] stated that mandibular third molars that were horizontally angulated had the most intimate relation with the IAC. In parallel to these researchers, in the present study there is a statistically significant relation between horizontal impaction and the presence of a relationship between the IAC and third molar.

In terms of diagnostic performance, three-dimensional imaging currently provides the best accuracy and is recommended when the panoramic radiograph presents one or more predictive markers. In panoramic radiography, when a clinician recognizes features suggesting a close relationship between the tooth's root(s) and the IAC, such as interruption of the radiopaque border and narrowing of the IAC according to the present study, CBCT should be used for detailed analysis.

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